https://doi.org/10.47262/BL/9.1.20230220

Review article
2023 | Volume 9 | Issue 1 | Pages 82-95

ARTICLE INFO

Received
April 01, 2023
Revised
May 31, 2023
Accepted
June 27, 2023

***Corresponding Author**
Sehrish Naz

E-mail
sehrishnaz647@gmail.com

Keywords
Light exposure
Circadian rhythms
DNA damage
UVA
Melatonin suppression

How to Cite
Naz S. Non visual and alerting impact of light on physiology of human body. Biomedical Letters 2023; 9(2):82-95.

Non visual and alerting impact of light on physiology of human body

Open

Sehrish Naz

Department of Zoology, University of Okara, Okara, Pakistan

Abstract

The human body and brain are affected by light both visually and non-visually. Light has extraordinary impact on large group of physiological capabilities, and encompass neuroendocrine regulation, sleep, alertness, cognition, and ocular reflexes, as well as phase-shifting and synchronization of the circadian framework. The blue light exposure is significant for keeping living organisms, cognitive performance prosperity and sharpness. The human eyes may suffer from excessive exposure of the blue light. The lack of light has a negative impact on sleep quality and alertness as well as mood, seasonal affective disorder and neurocognitive cycles. Early morning exposure to strong light delays the peak of melatonin production and alters cortisol, GH, PRL, and nocturnal vasopressin emission. Metabolic capabilities including the reducing levels of glucose resistance and diminished insulin sensitivity are horribly affected by night light exposure. Type 2 diabetes risk increases in an old populace due to the elevation in night light exposure. Ladies presented to night-light moves had sporadic monthly cycles that were much of the time related to dysmenorrhea and metabolic disorder insulin obstruction and liberation of glucose digestion. Estrus cycles, ovulation, sperm production, implantation, and the development of pregnancy are also affected by the desynchronizing effect of altered light signals on the circadian peripheral clocks in female and male conceptive tissues. DNA is harmed directly by UVB radiation. The present effort is to investigate and summarize the non-visual and alerting effect of light on the physiology of the human body.

Introduction

The human embodiment and brain are influenced by the light both ocularly as well as non-ocularly and are the fundamental for keeping the organic necessities of human body in balance [1]. The significance of light needs to be comprehends before studying the impacts of light on human physiology. Momentarily, the electromagnetic spectrum contains light which is radiation in a particular range. The light can arrive at illuminance up to 100,000 lux (lx) indirect daylight as well as 25,000 lx in full sunlight during the daytime. In blockade rooms, the light is used of impressively lower intensities and light of the intensity of 500 lx used in standard offices. The spectrum of light comes from the sun to earth and to sift to its dissemination. The geographical areas and seasons determine the accessibility of the light. Every hour of the day has access to the light in this modern era of the evolution of human beings through artificial light.

The counterfeit light takes into account enlightening the indoor and outside spaces. This artificial light comes in a variety of forms, such as halogen, neon and Light-emitting diode (LED) lighting. The basic spectra of light are fairly unique and may the light have shown up white. The motivation behind the various sorts of spectra could have a similar appearance lies in the retina. Basically, unique spectra, regardless of whether they make a similar visual impression, may change in their Chrono natural consequences for the circadian clock [2]. The light frequencies are designated as visible colors include red with 625-740 nanometers, orange with 590-625 nanometers, yellow with 565-590 nanometers, green with 520-565 nanometers, cyan with 500-520 nanometers, blue with 435-500 nanometers and violet with 380-435 nanometers. Infrared produces the impression of heat and has a wavelength range from 760 to 1 millimeter. The wavelength of Ultra-Violet (UV) is less than 400 nanometers [3].

There are numerous ways to measure the light and to study the exposure of light on human physiology. The illuminance is often reported during the distribution of absolute spectral light. A blackbody radiator with a similar spectrum to the light source in question possesses this connected variety of temperatures. A reference framework for evaluating the effects of light as nonvisual abilities was recently published by CIE, the body in charge of developing international standards for light-related quantities. By and by, experimenters utilizing light as an intercession ought to report, at any rate, the otherworldly power circulation of the light, as seen according to the perspective of the member [2]. Light has extraordinary impact on a large group of physiological capabilities, including phase-shifting and synchronization of the circadian framework, neuroendocrine control, sleeping, alertness, cognition, and ocular responses. Accordingly, the integrative lighting methodologies should think about the more extensive impacts of light on human wellbeing and execution [4].

The electromagnetic range of daylight is prevailed through microwave (49%) and infrared (49%) with visual (44 percent; 400-700nm range) and bright (UV; 7%;

10-400nm frequency). Most investigations on the natural impacts of daylight have shone on UV light [5]. At the blue end of the range, the blue light is the noticeable light. The shortest frequencies that can be seen by the human eye are found in blue light. The humans are routinely exposed to blue light since the sun emits it together with other colors of the spectrum. In any event, exposure to excessive amounts of blue light may harm the eyes [3]. The perceived wavelength range between ultraviolet (UV) and infrared (IR) radiation is 360 to 720 nm. The short (blue), medium (green), and long-frequency (red) radiation are terms used to describe visible light. Due to the high photon energy, blue light and UVA are referred to as near to UV, and high-energy visible (HEV). Blue light begins at 380 nm and ends at 500 nm. Both blue light from a natural source (the sun) and synthetic lighting can be identified. The ability to cause photochemical injury is made possible by the fact that photon energy is high. However, blue light essentially impairs non-visual abilities. The fact that blue light exists in both natural and synthetic light [1].

Circadian cycles, sleep, mood, and eyes affected by light exposure

The natural cycles of human have around 24-hour time spans are known as Circadian rhythms. People live in a steady environment with a regular sequence of light and darkness. The circadian rhythm possess sleep wake cycle that is important for the circadian rhythm [6]. The suprachiasmatic nuclei (SCN) in the hypothalamus functions as circadian pacemaker, synchronizes the internal biological rhythms with the 24-hour natural day. The ways of behaviors like rest during sleep and movement during attentiveness along with their basic organic cycles are influenced by rhythmic variations in encompassing brightening [2]. Human circadian rhythms are primarily controlled by light and serves as both a robust self-winding- winding indication and a helpful circadian rhythm to promote steady synchronization [7].

Being exposed to visible light, the suprachiasmatic nuclei of the hypothalamus synchronize the human biological clock to the 24-hour cycle based on sunlight. Most natural and psychological rhythms of circadian system synchronized internally by exposure and the arrow range wavelengths are most effective circadian synchronizers. Circadian beat is significant for the ideal capability of organic entities and circadian rest wake disturbances and persistent misalignment frequently may prompt mental and neurodegenerative disease. The brightness configuration, the duration of the entrance, and the intensity of the light affect the circadian synchronization, sleep quality, temperament, and cognitive function. The pineal gland produces melatonin, which is critical for regulating the circadian rhythm and must be suppressed by exposure to blue light during the day. Even though blue light exposure is crucial for biological organism continuing health, sharpness, and mental execution during the day, sleeps quality, circadian stage. The cycle duration may have serious ramifications and the constant exposure to the low intensity blue light occurs directly before sleep time. This ascents definitely the requirement for answers for further develop prosperity, sharpness, and mental execution in the present current culture [8].

Receptors types

Cones, rods, and naturally photosensitive retinal ganglion cells are the only types of photoreceptors that participate in photoreception in vertebrates (ipRGCs). However, the ipRGCs play a significant role in non-picture shaping photoreception. The photoreceptive framework regulates circadian photic entrainment, pupillary light reaction, and

other important biologic abilities. The old-style photoreceptors, such as rods and cones, are typically responsible for the photo articulating a vision [9].

Mechanism

The human brain has two main pathways for transmitting light information to its many different targets. The lateral geniculate nuclei (LGN), intergeniculate leaflet (IGL), and visual cortex of the occipital curve receive information through the visual channel, the optic nerve, chiasm, and plot. The retinohypothalamic tract (RHT) carries light data from the retina to the suprachiasmatic nuclei (SCN) in the hypothalamus. SCN serves as a natural clock in warm-blooded animals and has a number of downstream relationships despite other structures of the focused sensory system, such as the spinal line and brain. Additional nonvisual and independent of the circadian pacemaker administrative areas of the brain are activated by the RHT [2] (**Fig. 1**).

Effects of day and night light exposure

The effects of dawn light advance the clock, as opposed to the effects of evening and night light, which typically retard the clock. Light openness of adequately serious, the irradiance edges relying upon the frequency hindered melatonin discharge and decreased the circling melatonin levels. Melatonin levels remained maximally suppressed for about 15 minutes after interruption of the exposure and recovered after 15 minutes. Green light has less impact on suppression of melatonin level as compared to the blue light exposure. The impact arises in greatness as a component of time, circadian rhythm of melatonin and phase shift are occurred at equal degree. While blue and green light exposure impact is being free of the age. The phase shifting and the circadian rhythm of melatonin occur due to the discontinuous openings either to red light or to blue light. However, those lights did not repress the melatonin discharge. The phase shifting circadian rhythm of melatonin is not impacted by openness to blue light or blue enhanced light for one hour after get up in the first part of the day. The openness to blue light, the phase shift of the melatonin circadian rhythm was always provided to control a sleep promotion strategy. The two hours of light exposure before bedtime had no impact on the subsequent REM sleep. REM sleep was prolonged to expose the light for eight hours [10].

Blue Light exposure and effects on lens

Different lens components, including structural proteins, enzymes, and protein metabolites, absorb short wave light. The components and subordinates are added to the lens protein to provide yellow pigments, which gradually obliterate and turn the focal point yellow. Blue light is fundamentally more preserved by the focal point, preventing the anticipated retinal damage from blue light [11]. Due to indirect exposure to the blue light, the inflammatory

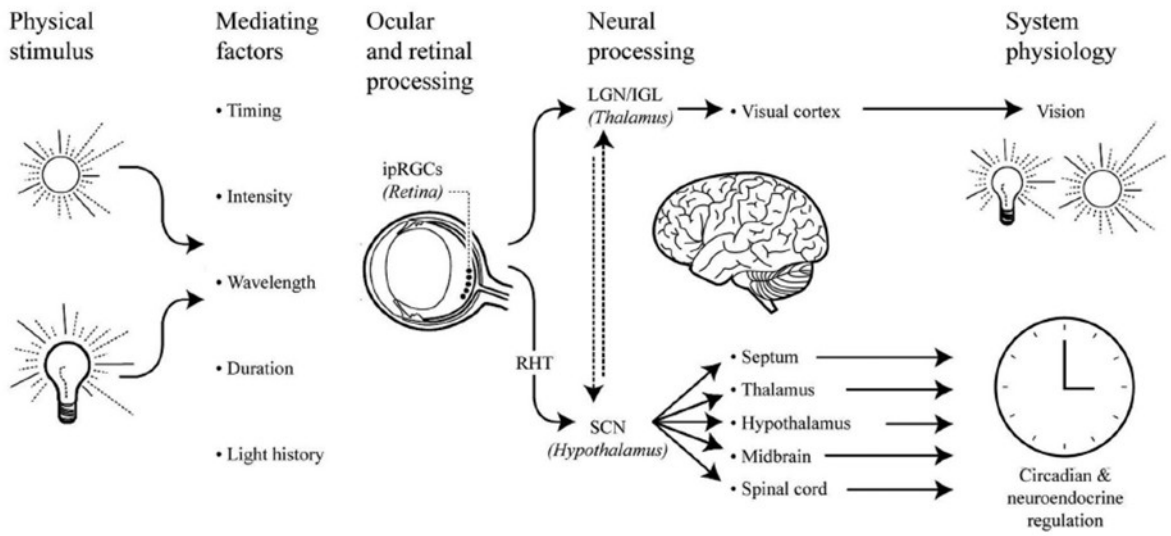

Fig. 1: Different spectrums for the transmitting of light and the brain system for transferring information [2].

reactions and photoreceptor cell loss follows the obliteration of the blood retinal barrier. Retinal pigments may degrade as a result of blue light [12]. The alpha 1D subunit may be activated by blue light exposure to cause damage to the cells of the retinal pigment epithelium [12].

Circadian rhythms impact by blue light exposure

The excessive exposure to blue light is at night leads to the melatonin production peaks. It can also activate the brain, suppress melatonin secretion, and increase the corticosteroid production, obliterating hormone release and adversely affecting the sleeping patterns [13]. Eye infections are linked to sleep quality. An increase in corticosteroid production brought on by sleep problems can reduce parasympathetic nerve arousal and decrease the tear production. It leads to the development of dry eyes. In addition, after a longer period of time, open eyes will result in an expansion of tear disappearing. This will produce dry eye adverse effects. Concurrently, blue light-induced sleep troubles to cause a decrease in eye closing duration [14]. More openness to the blue light has happened as the improvement in working and everyday environments and the progressions. A precise degree of blue light cannot only control a dark environment, while to reduce the growth of the eye hub to prevent the onset and progression of myopia. It is incorrect to generalize all blue light as directly harming the eyes and accomplishing unilaterally [15]. Blue light exposure can cause varying levels of damage to the cornea, the crystals focal, and the retina. The harmful effects on human eyes should not be overlooked [11].

Visual effects of light

The developing concern has happened to the unfavorable wellbeing effects of light around evening time in grown-ups [16]. Light openness in babies changes the pathways including the superchiasmatic nuclei in the hypothalamus and there is no change to the eye and retina [17]. The retina gets more susceptible to the blue light because the transparent material in the retina ages and the eye self-defense mechanism against blue light damaged.. One of the defenses against blue light exposure is the presence of RPE cells, which give the photoreceptors nutrients.

Although the RPE cells are not photosensitive, they are essential for the replenishment of visual pigments and for enhancing cone and rod activity. However, lipofuscin appears in the RPE cells of healthy human retinas at the age of ten. It can provide vision that is sturdy cell damage as it accumulates over time. Thus, in spite of the fact that RPE assists with recovering visual pigments, lipofuscin influence adversely this cycle [18].

Effect of Shorter wavelength light

The lower frequency light is known to generate Reactive Oxygen Species (ROS) in the retina when a light photon is unintentionally absorbed by a middle atom in the sight of oxygen. Long-term ROS accumulation includes lipofuscin. In addition to causing photochemical damage, ROS has been linked to the etiology of retinal degenerative diseases including Age-related Macular Degeneration (AMD). This leads to the death through apoptosis of RPE cells. ROS, free radicals, hydrogen peroxide, and singlet oxygen are incredibly responsive to their surroundings and well-equipped to cause damage to nearby and surrounding cells as well as macromolecules [1]. The essentially emit blue-advanced light, and the damaging system power peak is inside the range of blue light at 450 nm. After 39 weeks of exposure to LEDs at 450 nm, the Outer Nuclear Layer (ONL) has also been affected with only 4/5 of the 12/13 layers remaining intact. The destruction of photoreceptors results in sight loss and impaired night vision [19]. The intrinsically photo pigment retinal ganglion cells (ipRGCs) are involved in non-visual responses to light, contain melanopsin, and are most receptive between 420 and 480 nm. The maximum reasonable wavelengths for cones and rods, respectively, are 505 nm and 555 nm. Since each photoreceptor responds to light differently in terms of intensity and frequency, as well as in terms of light susceptibility and previous exposure to light [20]. The light reactions are controlled by ipRGCs during the initial receptivity to light. The more drawn out openness to light to short-frequencies more compelling is the readiness and execution [19].

Non-visual effects of light

Circadian rhythmicity is distinct from psychological capacity as it affects the ability of the body to regulate its temperature, endocrine, cardiovascular system, immune system, and ability to be alert. Lack of light has a negative impact on mood on neurocognitive cycles and may have a disconcerting impact on rest and alertness. Light also significantly affects the regions of strength that are responsible for dramatic changes in alertness, inclination to sleep, contemplation, mental performance, brain capacity, internal temperature, pulse, melatonin and cortisol release, gene expression, and pupil contraction [1].

Effect of light on hormones

Particularly as a synchronizing expert of hormonal rhythmicity among the exogenous natural parameters, the light appears to have a significant function in biological organisms [21]. Circadian musicality deals with the principal light responsive mind synthetics; melatonin and serotonin. Melatonin discharge for the most parts of the increments when the lights are switched off tops around midnight and step by step falls until the dawn. When plasma melatonin levels are high, sleep usually happens; when they are low, consciousness usually happens; and when the eyelids are closed, melatonin is not suppressed. Melatonin is released first, then the stress hormone cortisol from the adrenal cortex. The blue light has been shown to increase the alertness and speed up the data processing by lowering down the

melatonin levels. It is clear that natural and visual awareness have different responses to light; visual awareness reacts to light at a wavelength of 550 nm, while circadian rhythm responsiveness reacts at a wavelength of 460 nm. The workplace blue-advanced white illumination has positive impacts on daily performance, mood, eye strain, and the quality and length of nighttime sleep. Accordingly, the light sources with low frequencies can improve the visual comfort and sleep quality. The blue light reduces the physiological excitation and supports the notion to encourage the physiological rest by considerably lowering the breathing rate and diastolic blood pressure [15]. Although, altering the sleeping pattern reduces the vasopressin concentrations and affects the nightly top, exposure to bright light during the early long periods of gloom delays the evening melatonin peak and alters cortisol, GH, PRL, and nocturnal vasopressin secretion [22, 23, 24, 25].

Artificial light's impact on health

One sleepless night with room light exposure can negatively affect the glucose homeostasis, and most likely contribute to enhanced SNS stimulation. Regard for keeping away from openness to light around the evening time during sleep might be useful for cardio metabolic wellbeing [26]. A self-revealed artificial light exposure in the room during sleep time such as a little nightlight, light from the outside, or a TV or light in the room was associated with women heftiness, as opposed to no light exposure during the sleeping period. Most notably, those who reported falling asleep with a TV or light in the room experienced corpulence more frequently. The light exposure at night could have a detrimental effect on metabolic control [27].

Effect of light on metabolism

The night light openness horribly affecting the metabolic capabilities including diminished glucose resilience and diminished insulin responsiveness. The light openness assumes a part in human metabolic regulation. The light openness during the constant rest time frame while alert and during rest itself probably makes pernicious impacts on metabolism. A higher level of room light openness was linked to a higher incidence of type 2 diabetes in an elderly population [28]. The reduction of melatonin in the evening to the prevalence of diabetes and insulin resistance was observed. The melatonin emission is inhibited by the light exposure. The internal circadian framework may experience a phase change during the nighttime rest period as a result of light openness, even of modest intensity. The focal and peripheral clocks of metabolic tissues may become out of synchrony during the overnight sleeping phase [26].

Impact of Light on the nervous system

The degree of light openness has a major impact on ANS movement. The increase in cortisol and heart rate (HR) are associated with light exposure, particularly during the morning and evening time hours compared to night hours. The light exposure has an impact on the sympathetic autonomic framework. The changes to the Autonomic Nervous System (ANS) characterized by a shift toward an increased sympathetic response have also been advocated to mitigate the negative effects of sleep disruption on many physiological systems [26]

Heart, skin, and blood pressure impacted by light exposure

Occasionally occurring of cardiovascular transient groups seems to be impacted by daylight. The summertime blood pressure was consistently lower than wintertime throughout the preliminary tests for the Medical Research Council on hypertension. On the other hand, the cardiovascular mortality and gloom are more common in extreme cold months and are related to daylight availability. A CVD delay of up to 2.1 years is associated with higher levels of sun exposure in youth. Regardless of these fascinating discoveries that daylight openness might have defensive impacts with regards to cardiovascular wellbeing. The process by which light influences cardiovascular wellbeing are not surely known and should be adjusted against the adverse consequences of daylight [5].

Light causing skin cancer

There are conclusive evidence to support the notion that UV light is carcinogenic and contributes to the growth of melanoma and non-melanoma skin cancers by causing oxidative damage to lipids, co-enzymes, and DNA as single-strand breaks and protein-DNA crosslinks, and hastening skin maturation, although there are some known benefits [5].

Positive effect of UV light on BP, weight & metabolism

The UV-interceded photolysis of 7-dehydrocholesterol in the epidermis results in the subsequent steps of vitamin D production, is the most frequently acknowledged positive model. UV-induced photodecomposition occurs in human skin's nitrosated cysteine-rich proteins (RSNOs), nitrite, and other photolabile nitric oxide (NO) derivatives. This photolytically generated NO diffuses to deeper tissue layers and develops bioactivity, resulting in increased levels of metastable nitrous compounds (RXNOs) carried by blood circulation and lead to a prolonged reduction in circulatory strain. Additionally, UV light enhances practice performance by minimizing the weight growth and the negative impacts of metabolic disorders [5].

Effects of blue light on cardiovascular functions

Due to the well-known negative effects of UV light exposure, the organic effects of perceived blue light (420–453 nm) is not carcinogenic. The blue light stimulates non-enzymatic NO supply from cutaneous photolabile NO derivate, typically RSNOs, without inducing DNA strand breaks. Uncertainty exists regarding the extent to whole-body illumination with apparent non-cancerogenic blue light that can generate significant NO from the skin [5].

Human sympathetic nervous system response to bright light exposure

Muscle sympathetic nerve activity (MSNA) was recorded from the peroneal nerve in five sound participants to determine the effects of bright light on the sympathetic nervous system in humans. Each patient spent 20 minutes under 5000 lx of intense light. Following the wonderful light opening, MSNA proved to be significantly improved. Just as the dazzling light was beginning to shine, the heartbeat briefly increased. The bright light was opened, neither the systolic pressure nor its aftermath significantly changed. The primary visual indicator that strong light controls the sympathetic nervous system activity in typical humans [29].

Mechanism

The component of the improvement of MSNA brought about by the brilliant light is not evident. BP did not drop after the

strong light openness; it is improbable that the baro-reflex system played any role in MSNA. The upgrade may have contributed to focal process. The destruction of the suprachiasmatic nuclei, however, had the opposite impact (SCN). The retino-hypothalamic tract, which transmits nerve impulses to the SCN through the retina, has been shown to be activated by photic stimuli. Therefore, a few different brain nuclei that are crucial to a range of autonomic activities receive efferent filaments from the SCN. SCN may have a role in the MSNA upgrading leads to individuals having increased light sensitivity. Blood pressure did not rise as a result of MSNA formation brought on by bright light exposure. For instance, prolonged exposure to bright light may reduce the sympathetic nerves capacity to innervate the vascular bed of instinctual organs to modify the response of the arms and legs. The progressions dropped one another; net vascular opposition would not change. The sympathetic efferent innervating various organs act diversely after the bright light openness. The bright light exposure diminish the stroke volume and dropped the impact of expansion in vascular opposition [29].

Effect of light on vitamin D

In people, encompassing daylight assumes a significant part in vitamin D creation since high-energy UVB light enters the epidermis to convert the pre-vitamin D3 from pro-7-dehydrocholesterol with ensuing transformation to the steadier vitamin D3. Nutrient D3 is moved to the circulation and shipped to the liver. The significant record of body nutrient D3 stores before its last renal transformation to 1,25(OH)2D3. Among the various variables affecting cutaneous creation of nutrient D3 are occasional changes, level of skin pigmentation. Each 10° separation from the equator, there is an ever-evolving fall in surrounding UVB radiation and BP ascends at expanding good ways from the equator [30].

Effect of light on body temperature and BP

In temperate environment, the effects of seasonal variations have been observed with BP in wintertime. The encompassing UVB light exposure is at its highest in the summer. UVB exposure is at its lowest level. In BP to surrounding temperature, one more was more mindful in its understanding. It is conceivable that occasional and geographic changes in BP are contrarily connected with surrounding UVB light power. Additionally, past exploration announced that BP and PTH fell after UVB light [30] (**Fig. 2**).

Role of light in causing PCOS

Night-light exposure causes the irregular menstruation cycle in ladies that were regularly related to dysmenorrhea, metabolic disorder, insulin blockage, digestion of glucose emancipation which are all perceived factors for PCOS [31]. Circadian musicality disturbance is a significant factor for PCOS. The constant light openness causes elevation in the level of Anti Mullerian hormone (AMH). Constant light exposure brought about unhealthy glucose digestion and stomach microbial local area varieties, including a decline in the abundance of the corynebacterium, odoribacter, and acinetobacter. Constant light vulnerability, causes a significant natural variable, adds to the event and formative advancement in PCOS and alterations in the microbial component. One of the primary causes of PCOS is strongly associated with microbial design and functions [32, 33].

Effect of light on male and female reproductive system and genes

The rhythmicity may be disrupted by a shift in photoperiod of visual impairment. Circadian rhythmicity is significantly and synchronously influenced by the light exposure. The circadian peripheral clocks

are negatively impacted by the desynchronization of changed light exposure in male and female reproductive organs, which delays puberty and impairs ovulation, sperm production, implantation, and pregnancy development [34]. The

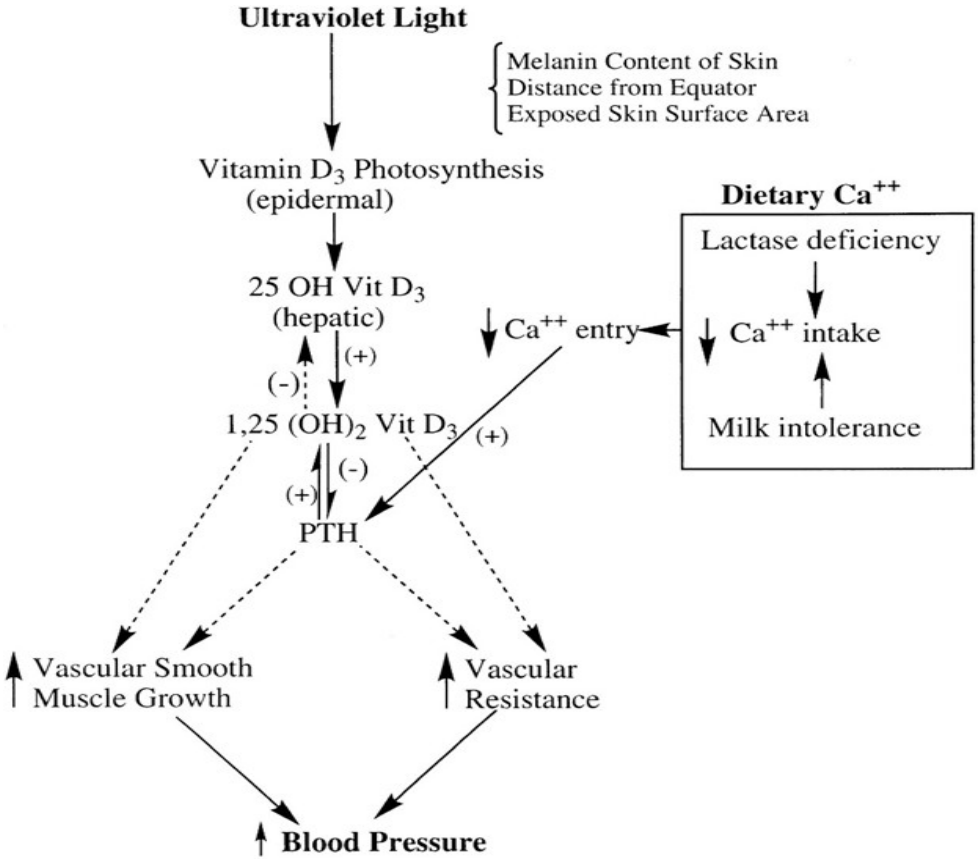

Fig. 2: Effect of light on blood pressure [30].

exposure to light may have an impact on sub-atomic level processes lead to the declaration of a few rapid early genes in the SCN involved with entrainment of the circadian clock. The genes are activated by exposure to light, transcription, and component of proteins linked to sub-atomic clock-resetting devices. The genes include the early-reaction genes (*c-fos* and *nur 77*) known to be activated in the SCN by light exposure. The zinc-finger transcript factor egr-3 activates by light to the ventral SCN. The light triggers the AP-1 activity and Jun-B mRNA articulation in the SCN. Furthermore, the light enhancement regulates the communication between the mammalian genes (*mper 1* and *mper 2*) to modulate the circadian rhythms in the SCN. In the postpartum rodent retina, the stimulus of light exposure activates the *C-fos* gene [35]. The light exposure resets the clock of genes related to clock regulation. In particular, the white collar-1 (*wc-1*) and white collar-2 (*wc-2*) act as global regulators of photoreactions in Neurospora, encode DNA-binding proteins that contain PAS spaces and act as transcriptional activators, thus playing a crucial role in the association of circadian rhythmicity [36].

Light impact on the hypothalamic-pituitary-gonad system

Through melatonin emission, which is regulated by exposure to visible light, the pineal organ disrupts the hypothalamic-pituitary-gonadal axis. Light input from the environment stimulates the retina to transmit the stimulation through a RHT to the SCN. The superior cervical ganglion, and eventually the pineal organ suppress the release of pineal melatonin. The darkness stimulates the pineal organ *alpha1* and *alpha2* adrenergic receptors, increasing cyclic AMP and calcium fixation and triggering the enzyme arylalkylamine nacetyl transferase to start the synthesis and arrival of melatonin [37]. The plasma and salivary melatonin decline equally in response to light exposure in the evening. The melatonin rhythmicity changes in patients with total vision impairment are more severe than in patients with merely light per subtitle. Strangely, a diminished occurrence of disease has been seen in blind individuals [38].

Effect of light on reproduction and role of seasonal variations

Animal sexual behaviors decreased throughout the periods of the year that have short days; such drop is prevented by pinealectomy [39]. Seasonal fluctuations in light intensity have an impact on various associated functions in both humans and animals, including melatonin secretion. A region with a sharp seasonal brightness contrast displayed increased melatonin and decreased gonadotropin release during the dark season. Patients with both essential and optional hypogonadism have also demonstrated sporadic forms of plasma LH and T fixations. Furthermore, the elevated plasma melatonin levels and decreased plasma gonadal capacity can be impacted in people by visual impairment [36].

Endocrine secretions and the consequences of light exposure

The favorable gonadal capability found in both animals and humans are impacted by stimuli of light and light exposure, reasonable through hindrance of melatonin discharge. All things being equal, the decrease of light exposure in people can promp. These modifications appear to be more extreme when the visual deficiency happens in the principal long stretches of life [36].

Erythema and pigmentation impact by light exposure

The effects of UV radiation, visible light and infrared radiation on cutaneous erythema, rapid pigment darkening, persistent pigment darkening, and delayed tanning are influenced by a variety of circumstances. The factors include things like the depth of cutaneous entry of the specific frequency, the type of skin an individual has, and the retention spectra of the various chromophores in the skin. Erythema can be activated by UVB and delayed tanning follows. The rapid pigment darkening, continuous pigment darkening, and delayed tanning are all caused by UVA. UVA (mostly UVA2) at high doses can also cause erythema in those with skin type’s I–II. The visible light has been shown to cause erythema and a tanning reaction in those with dark skin. Erythema is probably a thermal effect brought on through infrared radiation. Various UVR spectra have unique effects on the epidermis design and thickness, as well as on the epidermis ability to contain melanin. Numerous factors, including the duration of the exposure, specific chromophores, dose of each wavelength, constitutional skin type, and pre-exposure skin pigmentation, interact during the

exposure process. It is now known that visible light causes pigmentation and erythema on people with darker skin tones [40].

UV radiation effects on erythema and pigmentation

The clinical effects of UV radiation exposure include erythema, pigment darkening, delayed tanning, thickening of the epidermis, and the production of vitamin D. The skinned erythema results from sunburn and is a burning reaction by warmth and sensitivity. Severe erythema can result in the creation of rashes. Light from the sun may cause a brief erythematous blush to appear during and after exposure in those with light skin tones. In all skin types, a delayed erythema reaction that peaks between 6 and 24 hours is usual. A biphasic reaction can be seen in shaded concealing, which should be distinguished from delayed tanning. After being exposed to UVA, there is an instantaneous pigment darkening (IPD) that may persist for as long as two hours. IPD is more prevalent in PPD, to genetic causes, and darker skin tones [41].

Chronic effects on skin carcinogenesis

Although the immediate effects of UV exposure on the skin, such as erythema, pigment darkening, and tanning, are obvious, ongoing damage may eventually make one more susceptible to the long-term negative effects of UVR exposure, such as immunosuppression, photo carcinogenesis, deep wrinkles, leathery skin, dilated blood vessels, and numerous dark spots on the skin. Skin cancer is the most prevalent type of cancer, and both melanoma and non-melanoma skin cancers are escalating. Over a million new instances of NMSC are thought to be diagnosed annually. Sun rays exposure, particularly squamous cell carcinoma is certainly connected to NMSC [42].

Effect of UVB on DNA

Cyclobutane-pyrimidine dimers and thymine dimers are the results of UVB radiation direct DNA damage. DNA damage caused by UVA radiation is mediated by ROS to produces oxidative products including 7, 8-dihydro-8-oxo-guanosine (8-oxoG) and 8, 7-, 8-dihydro-2′-deoxyguanosine (8-oxo-dG). Skin cancer develops as a result of defective DNA transcription and the elimination of the mutagenic photoproducts, which causes unchecked cellular proliferation [43].

Effect of UVR on immune system

UVR-prompted immunosuppression is a significant component for photograph carcinogenesis, as confirmed by the expanded paces of skin malignant growth in immunosuppressed patients. An experiment revealed that UVR exposure reduces the number and capacity of T lymphocytes in peripheral blood and Langerhans cells in the epidermis. The advancement of UVR-prompted skin malignant growth is due to blending of direct DNA harm [41].

Effect of UVR on epidermis

The epidermis, in particular the dermis and, to a lesser extent, the innermost layer stratum corneum thickens as a result of UVR exposure. The epidermis has a large number of UVR chromophores. The components of melanin, uranic acid, aromatic amino acids, and nucleic acids are among these. The chromophore for UVR-induced erythema is known to be DNA. The erythema action spectrum and the action spectrum of UV-activated DNA damage have the same aspect for frequencies below 320 nm [44].

Effect of UVB on skin

UVB wavelengths range from 280 to 315 nm. UVB sources with specific frequencies between 311-313 nm are frequently employed in laser therapy. The amount of UVB radiation is approximately 5%, however, despite its relatively infrequent frequency, it may still be detrimental to the skin. The wavelength range associated with skin cancer is between 280 and 320 nm. UVB is a group of frequencies that has been proven to be carcinogenic. It is known that UVB light exposure at 290 nm causes skin cancer. Specifically, might bring about additional dangerous impacts contrasted with UVB of longer frequencies [42].

UVB exposure induces erythema

The erythemogenic effect of UVB light exposure is stronger than the melanogenic effect. The minimal erythema dose (MED) for UVB radiation is 1000-overlay for Caucasian skin, which is not quite the same as the MED for UVA irradiation. Erythema brought on by UVB peak value lasting six to twenty four hours. Skin type affects the progression and severity of UVB-induced erythema UVB dosage and UVB frequency. Hardly skin types I and II show a rapid erythemogenic reaction [45]. The erythema induced by UVB exposure has been shown to go away in dark skin after 1-3 days, whereas erythema in lighter skin persists for 1-2 weeks. Darker skin tones require a higher UVB dose to cause minimum erythemasince [40].

UVB other impacts

By expanding the superficial blood vessels in the dermis, UVB radiation causes erythema in the skin. Vasodilation is thought to be brought on by the cytokines, histamine, prostaglandins, and inflammatory mediators that UVB light causes to be produced into the skin. Cyclobutane pyrimidine dimers (CPDs) and thymine dimers are the two primary DNA photoproducts that result from exposure to UVB. The UVB signature mutation (C T or CC TT) in the *p53* was found in the majority of actinic keratosis (AKs), squamous cell carcinomas (SCCs), and over half of basal cell carcinomas (BCCs) [46].

Melanoma causing by UVB exposure

Additionally, UVB receptivity may contribute to melanoma development. UVA is less potent in imitating the melanoma in the skin as compared to the UVB exposure and this is accomplished to specific DNA damage brought on by UVB radiation [47].

Benefit of UVB exposure

The range of UVB at 300 to 5 nm is responsible for cutaneous vitamin D synthesis to be crucial for significantly affect a number of diseases and crucial for bone health [48] (**Table 1**).

UVA exposure induces pigmentation

UVA radiation causes erythema, pigment darkening (both IPD and PPD), and delayed tanning (DT) more effectively than UVB exposure. The skin with a

Table 1: Various categories of light exposure and effect on physiology

Light exposure categories	Effects on Physiology
Continuous light exposure	Induce the Changes in the pathway of SCN in newborns Affects the sympathetic autonomic nervous system Increase cortisol level Increase heart rate Abnormal glucose metabolism Causes gut microbial community variations
Blue light	Causes eye injury Harmful to the eyes

	Stifle melatonin emission Harmful effects on sleep quality, circadian rhythms, cycle duration Initiate debasement of retinal pigments Excessive exposure causes retinal damage Stimulates the brain Inhibit melatonin secretion Increase corticosteroid production Induce sleep disorders Dry eye symptoms Causes Damage to the retina, cornea as well as to the crystal lens Plays role in Prevention of Myopia occurrence and its development. Plays role in regulation of the circadian rhythms Reduces heartbeat Reduces diastolic Blood pressure
Desynchronizing altered light	Influences circadian peripheral clock in male & female reproductive tissues Causes impairment of fertility Causes estrous cycle disorders Causes estrous ovulation disorders Causes sperm production disorders Causes implantation & progression of pregnancy disorders Causes periodic insomnia
Bright light	Delays nocturnal melatonin peak Alters the cortisol level Alters the GH level Alters the PRL level Alters the nocturnal vasopressin secretion level
No light	Negatively affected the mood Causes SAD (seasonal affective disorders) Negative effect on neurocognitive processes Shortened the gestation period Induces hypogonadism Delays puberty
Artificial light	Causes obesity in females Causes diabetes type 2 Causes PCOS
Evening light	Decreases glucose tolerance Decreases insulin sensitivity Irregular menstruation cycle Defers the clock
Day LIGHT	Vitamin D synthesis Propels the clock
Dim light	Causes anxiety disorders Causes Bipolar disorders in newborns
UV	UV light is cancerogenic Causes melanoma & non-melanoma skin cancer
UVA	Accelerates the instantaneous darkening of pigment Leads to enduring pigment darkening Promotes deferred tanning
UVB	Induces erythema & delayed tanning Directly damages DNA UVB is more erhythmogenic than melanogenic Induces erythema Causes the vasodilation in the dermis's superficial blood vessels
UVR	Leads to the inhibition of T lymphocytes in peripheral blood as well as Langerhans cells, or antigen-presenting cells, in the epidermis. Induces skin cancer Causes the thickening of the epidermis
IR	Induces erythema Induces photo aging Causes skin wrinkling Decreases anti-oxidant enzyme activity

brown complexion has more prominent IPD, PPD, and DT as compared to the light skin complexions. In all skin types, UVA causes an IPD effect. IPD is limited in its range and occurs in milliseconds upon exposure to UVA radiations as well as visible light up to 470 nanometers range and fades between a few seconds to a maximum of two hours [45]. UVA-activated melanin retrieval in the basal cell layer expressed with frequencies between 340 and 400 nanometers. [40].

Molecular effects of UVA

Due to the existence of melanin and precursors in the manufacture of melanin, UVA openness may have harmful effects. ROS can be produced by melanin in response to UVA exposure to trigger the DNA single-strand breaks. ROS are cytotoxic and capable of causing cell death in high quantities [47].

Benefits of UVA

The exposure to UVA radiation causes an increase in heme oxygenase-1 concentration in the skin, and this enzyme possesses soothing and cell-reinforcing capabilities. UVA causes the skin to release nitric oxide. UVA exposure influences the cardiovascular benefit to be attributed to the skin production of nitric oxide, nitrite and nitrate. Nitric oxide is an ephemeral free radical and does not cause much harm. [49].
IR induced photoaging
The cutaneous impacts of IR exposure cause severe photo damage as compared to the blending of both IR and UV. The skin might cause the skin wrinkling through heat-initiated expanded articulation of matrix metalloproteinase and also the reduction of the antioxidant enzyme activity by chronic intensity exposure. IR-initiated photoaging might be the consequence of an unsettling influence of the electron stream of the mitochondrial electron transport chain. IR has likewise been displayed to invigorate angiogenesis and increment the quantity of mast cells, the two of which have been related with skin maturing [50].

Effect of IR- exposure in cytotoxicity and DNA damage

Concentrating on the effects of IR exposure is that *in vivo* human skin fibroblasts is impacted by IR exposure, an investigation exhibited that IR light incited an enduring fractional security from UVA-and UVB-initiated cytotoxic harm. DNA damage and IR exposure are linked [51]. DNA damage including the *in vitro* cells of human skin actuated by UVB exposure [40].

Effect of IR exposure on free radicles

The free radicles did not incite by the IR open a temperature of 37 °C, nonetheless, free radicles were initiated at temperatures of 39 °C or higher [52].

Conclusion

The human body and brain are affected by light both visually and non-visually. The light exposure induces healthy as well as harmful impacts on the human body. Light can extraordinarily impact a large group of physiological capabilities, such aspupillary responses, mood, memory, learning, sleeping cycle regulation, alertness, regulation of neuroendocrine system, phase shifting of circadian system and circadian entertainment. The openness to blue light is significant for keeping living organisms prosperity, sharpness, and cognitive performance during the day. Additionally, the light causes serious and significant changes in the body temperature, heart rate, melatonin and cortisol secretion, gene expression, pupil constriction, alertness, sleep propensity, attention, cognitive performance and cognitive brain function.

Acknowledgements

Author is thankful to Muhammdan Laboratory of Computational Biology, Pakistan for guidance throughtout this project.

Conflict of interest

The authors declare no conflict of interest.

References

[1] Gomes CC, Preto S. Blue Light: A Blessing or a Curse? Procedia Manufacturing.2015;3:4472-4479.
[2] Blume C, Garbazza C, Spitschan M. Effects of light on human circadian rhythms, sleep and mood. Somnologie - Schlafforschung und Schlafmedizin.2019.
[3] Abokyi S, To CH, Lam TT, Tse DY. Central Role of Oxidative Stress in Age-Related Macular Degeneration: Evidence from a Review of the Molecular Mechanisms and Animal Models. Oxid Med Cell Longev.2020;2020:7901270.
[4] Vetter C, Pattison PM, Houser K, Herf M, Phillips AJK, Wright KP, Skene DJ, Brainard GC, Boivin DB, Glickman G. A Review of Human Physiological Responses to Light: Implications for the Development of Integrative Lighting Solutions. LEUKOS.2022;18(3):387-414.
[5] Stern M, Broja M, Sansone R, Gröne M, Skene SS, Liebmann J, Suschek CV, Born M, Kelm M, Heiss C. Blue light exposure decreases systolic blood pressure, arterial stiffness, and improves endothelial function in humans. European Journal of Preventive Cardiology.2020;25(17):1875-1883.
[6] Yates J. PERSPECTIVE: The Long-Term Effects of Light Exposure on Establishment of Newborn Circadian Rhythm. Journal of clinical sleep medicine : JCSM : official publication of the American Academy of Sleep Medicine.2018;14(10):1829-1830.
[7] Roenneberg T, Kantermann T, Juda M, Vetter C, Allebrandt KV. Light and the human circadian clock. Handb Exp Pharmacol.2013(217):311-31.
[8] Wahl S, Engelhardt M, Schaupp P, Lappe C, Ivanov IV. The inner clock-Blue light sets the human rhythm. Journal of biophotonics.2019;12(12):e201900102-e201900102.
[9] Tosini G, Ferguson I, Tsubota K. Effects of blue light on the circadian system and eye physiology. Molecular vision.2016;22:61.
[10] Tähkämö L, Partonen T, Pesonen A-K. Systematic review of light exposure impact on human circadian rhythm. Chronobiology International.2019;36(2):151-170.
[11] Zhao ZC, Zhou Y, Tan G, Li J. Research progress about the effect and prevention of blue light on eyes. Int J Ophthalmol.2018;11(12):1999-2003.
[12] Li H, Cai S, Gong X, Wu Z, Lyn J, Su G, Xie B. [The effect of blue light on human retinal pigment epithelium cells α1D subunit protein expression and vascular endothelial growth factor and basic fibroblast growth factor secretion in vitro]. Zhonghua Yan Ke Za Zhi.2014;50(11):814-9.
[13] Gabel V, Reichert CF, Maire M, Schmidt C, Schlangen LJM, Kolodyazhniy V, Garbazza C, Cajochen C, Viola AU. Differential impact in young and older individuals of blue-enriched white light on circadian physiology and alertness during sustained wakefulness. Sci Rep.2017;7(1):7620.
[14] Zizi F, Jean-Louis G, Magai C, Greenidge KC, Wolintz AH, Heath-Phillip O. Sleep complaints and visual impairment among older Americans: a community-based study. J Gerontol A Biol Sci Med Sci.2002;57(10):M691-4.
[15] Münch M, Nowozin C, Regente J, Bes F, De Zeeuw J, Hädel S, Wahnschaffe A, Kunz D. Blue-Enriched Morning Light as a Countermeasure to Light at the Wrong Time: Effects on Cognition, Sleepiness, Sleep, and Circadian Phase. Neuropsychobiology.2016;74(4):207-218.
[16] Lunn RM, Blask DE, Coogan AN, Figueiro MG, Gorman MR, Hall JE, Hansen J, Nelson RJ, Panda S, Smolensky MH, Stevens RG, Turek FW, Vermeulen R, Carreón T, Caruso CC, Lawson CC, Thayer KA, Twery MJ, Ewens AD, Garner SC, Schwingl PJ, Boyd WA. Health consequences of electric lighting practices in the modern world: A report on the National Toxicology Program's workshop on shift work at night, artificial light at night, and circadian disruption. The Science of the total environment.2017;607-608:1073-1084.
[17] Brooks E, Canal MM. Development of circadian rhythms: role of postnatal light environment. Neurosci Biobehav Rev.2013;37(4):551-60.
[18] Cuthbertson FM, Peirson SN, Wulff K, Foster RG, Downes SM. Blue light-filtering intraocular lenses: review of potential benefits and side effects. J Cataract Refract Surg.2009;35(7):1281-97.
[19] Peng M, Tsai C-Y, Chien C-L, Hsiao JC-J, Huang S-Y, Lee C-J, Lin H-Y, Wen Y-C, Tseng K-W, editors. The Influence of Low-powered Family LED Lighting on Eyes in Mice Experimental Model. 2012.
[20] Smith MR, Revell VL, Eastman CI. Phase advancing the human circadian clock with blue-enriched polychromatic light. Sleep Med.2009;10(3):287-94.
[21] Bellastella A, De Bellis A, Bellastella G, Esposito K. Opposite influence of light and blindness on pituitary–gonadal function. Frontiers in endocrinology.2014;4:205.
[22] Kostoglou-Athanassiou I, Treacher DF, Wheeler MJ, Forsling ML. Bright light exposure and pituitary hormone secretion. Clin Endocrinol (Oxf).1998;48(1):73-9.
[23] Nir I, Hirschmann N. Effect of constant light and darkness on pituitary and serum

gonadotropin and sex hormone levels of parturient rats. Journal of Neural Transmission.1982;55(2):157-168.
[24] Lewis P, Erren TC. Perinatal Light Imprinting of Circadian Clocks and Systems (PLICCS): The PLICCS and Cancer Hypothesis. Frontiers in Oncology.2017;7.
[25] Khanzada NS, Butler MG, Manzardo AM. GeneAnalytics Pathway Analysis and Genetic Overlap among Autism Spectrum Disorder, Bipolar Disorder and Schizophrenia. Int J Mol Sci.2017;18(3).
[26] Mason IC, Grimaldi D, Reid KJ, Warlick CD, Malkani RG, Abbott SM, Zee PC. Light exposure during sleep impairs cardiometabolic function. Proceedings of the National Academy of Sciences.2022;119(12):e2113290119.
[27] Park YM, White AJ, Jackson CL, Weinberg CR, Sandler DP. Association of Exposure to Artificial Light at Night While Sleeping With Risk of Obesity in Women. JAMA Intern Med.2019;179(8):1061-1071.
[28] Fonken LK, Nelson RJ. The Effects of Light at Night on Circadian Clocks and Metabolism. Endocrine Reviews.2014;35(4):648-670.
[29] Saito Y, Shimizu T, Takahashi Y, Mishima K, Takahashi K-i, Ogawa Y, Kogawa S, Hishikawa Y. Effect of bright light exposure on muscle sympathetic nerve activity in human. Neuroscience Letters.1996;219(2):135-137.
[30] Rostand SG. Ultraviolet light may contribute to geographic and racial blood pressure differences. Hypertension.1997;30(2):150-156.
[31] Chu W, Zhai J, Xu J, Li S, Li W, Chen Z-J, Du Y. Continuous Light-Induced PCOS-Like Changes in Reproduction, Metabolism, and Gut Microbiota in Sprague-Dawley Rats. Frontiers in microbiology.2020;10:3145-3145.
[32] Chu W, Zhai J, Xu J, Li S, Li W, Chen Z-J, Du Y. Continuous light-induced PCOS-like changes in reproduction, metabolism, and gut microbiota in Sprague-Dawley rats. Frontiers in microbiology.2020;10:3145.
[33] Kang X, Jia L, Shen X. Manifestation of hyperandrogenism in the continuous light exposure-induced PCOS rat model. BioMed Research International.2015;2015.
[34] Sellix MT. Clocks underneath: the role of peripheral clocks in the timing of female reproductive physiology. Frontiers in Endocrinology.2013;4:91.
[35] Albrecht U, Sun ZS, Eichele G, Lee CC. A differential response of two putative mammalian circadian regulators, mper1and mper2, to light. Cell.1997;91(7):1055-1064.
[36] Bellastella A, De Bellis A, Bellastella G, Esposito K. Opposite influence of light and blindness on pituitary-gonadal function. Front Endocrinol (Lausanne).2014;4:205.
[37] Czeisler CA, Shanahan TL, Klerman EB, Martens H, Brotman DJ, Emens JS, Klein T, Rizzo JF. Suppression of melatonin secretion in some blind patients by exposure to bright light. New England Journal of Medicine.1995;332(1):6-11.
[38] Lockley SW, Skene DJ, Arendt J, Tabandeh H, Bird AC, Defrance R. Relationship between melatonin rhythms and visual loss in the blind. The Journal of Clinical Endocrinology & Metabolism.1997;82(11):3763-3770.
[39] Reiter RJ. Pineal melatonin: cell biology of its synthesis and of its physiological interactions. Endocrine reviews.1991;12(2):151-180.
[40] Sklar LR, Almutawa F, Lim HW, Hamzavi I. Effects of ultraviolet radiation, visible light, and infrared radiation on erythema and pigmentation: a review. Photochem Photobiol Sci.2013;12(1):54-64.
[41] Schmalwieser AW, Wallisch S, Diffey B. A library of action spectra for erythema and pigmentation. Photochemical & Photobiological Sciences.2012;11(2):251-268.
[42] Gloster HM, Jr., Neal K. Skin cancer in skin of color. J Am Acad Dermatol.2006;55(5):741-60; quiz 761-4.
[43] Maddodi N, Jayanthy A, Setaluri V. Shining light on skin pigmentation: the darker and the brighter side of effects of UV radiation. Photochem Photobiol.2012;88(5):1075-82.
[44] Pearse AD, Gaskell SA, Marks R. Epidermal changes in human skin following irradiation with either UVB or UVA. J Invest Dermatol.1987;88(1):83-7.
[45] Hönigsmann H. Erythema and pigmentation. Photodermatol Photoimmunol Photomed.2002;18(2):75-81.
[46] Brash DE. Roles of the transcription factor p53 in keratinocyte carcinomas. Br J Dermatol.2006;154 Suppl 1:8-10.
[47] Noonan FP, Zaidi MR, Wolnicka-Glubisz A, Anver MR, Bahn J, Wielgus A, Cadet J, Douki T, Mouret S, Tucker MA. Melanoma induction by ultraviolet A but not ultraviolet B radiation requires melanin pigment. Nature communications.2012;3(1):1-10.
[48] Vanchinathan V, Lim HW, editors. A dermatologist's perspective on vitamin D. Mayo Clinic Proceedings; 2012: Elsevier.
[49] Feelisch M, Kolb-Bachofen V, Liu D, Lundberg JO, Revelo LP, Suschek CV, Weller RB. Is sunlight good for our heart? European heart journal.2010;31(9):1041-1045.

[50] Krutmann J, Morita A, Chung JH. Sun exposure: what molecular photodermatology tells us about its good and bad sides. Journal of Investigative Dermatology.2012;132(3):976-984.
[51] Menezes S, Coulomb B, Lebreton C, Dubertret L. Non-coherent near infrared radiation protects normal human dermal fibroblasts from solar ultraviolet toxicity. Journal of investigative dermatology.1998;111(4):629-633.
[52] Jung T, Höhn A, Piazena H, Grune T. Effects of water-filtered infrared A irradiation on human fibroblasts. Free Radical Biology and Medicine.2010;48(1):153-160.